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Why Explicit Performance Bonds Are Absent from Employment Contracts

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ABSTRACT

We provide an explanation for the absence of explicit bonds in employment contracts subject to shirking moral hazard. We consider a game between a firm and its workers, where the firm's marginal productivity of labor is diminishing. We show that if the firm cannot credibly commit to an acceptable level of employment, contracts that involve explicit bonds cannot be self-enforcing. The reason is that with positive up-front receipts from workers, the firm's payoff from cheating rises without bound as employment grows, while the lifetime payoff from honesty is bounded. If credible commitment to employment is feasible at sufficiently low cost, the firm's gain from cheating can be contained and equilibria where the firm captures most of the surplus from employment through bonding become feasible.

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1. Introduction

Efficiency wage models, popularized in the early 1980s, remain today the pre-eminent explanation for otherwise unaccountable wage premia. For example, see Oswald and Blanchflower (1993) and Krueger and Summers (1988). Yet it is still a mystery, from a theoretical perspective, why firms pay efficiency wages rather than have their employees post performance bonds. In the heavily cited papers by Shapiro and Stiglitz (1984) and Bulow and Summers (1986), efficiency wages are assumed rather than derived, by ruling out performance bonds *a priori.* This is precisely the point made by Carmichael (1985). Indeed, other authors—e.g., Lazear (1981) and Murphy and Topel (1990)—prefer the exact opposite assumption. They argue that bonding contracts are feasible and can generate first best employment because firm malfeasance can be controlled by the firm's concern for its reputation. Carmichael (1990) goes further to argue that since the efficency wage models cannot explain away bonds, the models have failed the purpose for which they were designed.

MacLeod and Malcomson (1989), hereafter M&M, examine performance contracts with the possibility of bonding. They model the employment relationship as a generalized, repeated "Prisoner's Dilemma." M&M conclude that it is necessary *and sufficient* for the present value of the *future* surplus to exceed the *current* disutility of effort, to sustain effort in equilibrium. Then, either party can capture this future surplus or it can be divided in any fashion between them, depending on prior beliefs.

In the M&M model, detection of worker shirking is certain. When detection is stochastic, as in the Shapiro and Stiglitz or Bulow and Summers model, the size of the requisite surplus increases with the probability of shirking going undetected. When the detection probability is low and the firm captures the surplus, there must be an up-front payment made from the worker to the firm; i.e., there must be explicit bonding. But this poses a dilemma, since explicit bonding is extremely rare in actual labor contracts. Hence, either moral hazard is a minor problem in employment relationships or the existing models are not well specified.

The goal of this paper is to provide an explanation for why workers must capture enough of the surplus to rule out explicit bonding. We consider a model similar to that of M&M, but with random detection. More importantly, we allow a firm to hire many workers, where employment is subject to the usual diminishing marginal productivity assumption.. As a

result, it is necessary to aggregate across all employees of the firm when the surplus condition is derived in our model. When the firm cannot credibly commit to an acceptable level of employment, contracts that involve explicit bonds always violate the surplus condition. The reason is that with positive up-front receipts from workers, the firm's payoff from cheating rises without bound as employment grows, while the lifetime payoff from honesty is bounded. Of course, if credible commitment to employment is feasible at sufficiently low cost, the firm's gain from cheating can be contained and results equivalent to those of the M&M model will obtain.

A number of other explanations for the absence of bonding have been suggested in the literature, but we find these explanations somewhat deficient. For instance, MacLeod and Malcomson (1992) argue correctly that in market equilibrium, maximal matching necessitates agents on the long side capturing all the surplus from a match. They then go on to argue that the efficient matching condition dictates the division of the surplus.[1] But, as we show in Arvan and Esfahani (1992), agents on the short side do not internalize the benefit from an increased number of matches and, consequently, it is not obvious that contracts will be written so as to give all the surplus to agents on the long side.

We too have provided an alternative explanation, in Arvan and Esfahani (1993), based on firm private information, where the wage and employment are used as signals.[2] But this signalling explanation is incomplete. First, recurring innovations in the firm's private information are necessary, to sustain efficiency wages over time. Otherwise, as this information becomes commonly known, the contract wage will tend toward the reservation wage and employment will adjust to the complete information optimum. This point has been made by Bagwell and Riordan (1991), in the context of a firm signalling product quality. Second, as in M&M, we consider bilateral contracting only. Though we allow employment to vary, this is achieved by varying the number of hours, not the number of employees. The Shapiro-Stiglitz and Bulow-Summers models consider firms that hire many workers. Consequently, it is interesting to ask whether the M&M conclusions hold when firms are capable of varying employment. This is the concern of the present paper.

Since we base our explanation for why workers must capture some of the surplus on the

[1] This argument is reiterated in Malcomson (1992).

[2] A similar signalling story is given by Beaudry (1990) who considers turnover moral hazard rather than worker shirking.

lack of ability to commit to an employment level, it is worthwhile to examine when this lack of commitment assumption is reasonable. In much of the related literature, commitment is synonymous with verifiability. Contractual commitments are enforced by the courts. Commitments are restricted to only what the courts can observe. Typically, it is *assumed* that whatever the courts can observe is enforceable in a contract, because the courts can mete out sufficient punishment to ensure compliance. See, for example, M&M, Hermalin and Katz (1991), and Huberman and Kahn (1988).

Certainly, it seems reasonable to assume that a court could observe firm employment, were it requested to do so, though we think it important to note that there may be a lag in verification.[3] This lag is crucial because it bears on whether the court can punish appropriately. Commitment is possible when the bonds the firm expropriated from its employees are available to pay the fine imposed by the courts. Instead, these bonds may have been consumed or spent in ways impossible to recover (e.g., paying supplier commisions, legal fees, etc.). Thus, commitment to employment is reasonable if there is a very short lag in verification, so that the firm doesn't have a chance to "eat" the bonds. Otherwise, and we think this often is the case, commitment to employment is unreasonable and the results of our model hold.[4]

Our argument is based on the assumption that the firm does not incur a large cost when it cheats through excessive employment and subsequent expropriation of the bonds. Such an adjustment cost, were it to exist, might be more effective than the courts as an employment commitment mechanism. The adjustment cost must exceed the bond, on a per worker basis, and must be incurred prior to new employees posting the bond, to constrain the firm from cheating. For the bulk of industrial employment, we do not find the assumption of a large adjustment cost very plausible. In most instances, a firm could create a variety of positions

[3] Indeed, for our argument to work even employees must observe employment with a lag. Otherwise, they would always reject a contract where employment is so great that the surplus condition is violated.

[4] The presumption here is that commitment to an employment level is desireable. In reality, it may be preferable to have employment flexible in the presence of uncertainty, when commitment to state-contingent employment is not feasible because of menu costs, private information, or some combination of the two. We ignore uncertainty to keep the model simple. But we note that if it is optimal to allow employment to be flexible, then it may be necessary for employees to capture much of the surplus, to assure them that the firm won't act as a miscreant in selecting employment.

that are almost costless to set up, especially if the firm intended to cheat on its employees.

This explanation for the lack of bonding in actuality, based on the firm's inability to commit to the size of its workforce qua verification lags and limited firm liability, stands in contrast with earlier explanations for the lack of bonding based on the workers' inability to post performance bonds owing to liquidity constraints. See Akerlof and Katz (1989) and Eaton and White (1982). The explanation based on liquidity constraints runs afoul of the facts in predicting steep wage-earnings profiles and a firm preference for more liquid workers. See Abraham and Farber (1987) and Altonji and Shakotko (1987). The explanation based on lack of firm commitment ability doesn't suffer these drawbacks and, in addition, suggests that actual wages should depend, in large part, on firm productivity. In contrast, the efficiency wage model of Shapiro and Stiglitz as well as the model of Bulow and Summers predict that the wage depends on the monitoring intensity, but is otherwise independent of productivity.

The remainder of the paper is organized as follows. In section 2, we develop a benchmark model with fully enforceable employment commitment that demonstrates the possibility of explicit bonding. In section 3, we show that introducing a liability limit on the firm rules out explicit bonding. Moreover, all self-enforcing contracts involve some job rent for the employees when the detection probability is low. Finally, in section 4, we offer some concluding remarks.

2. The Model with Employment Commitment

The model developed in this section depicts a game between a firm and its workers in the context of a labor market with a continuum of identical workers. The market is a discrete-time, infinite-horizon, stationary environment. All agents are infinitely-lived and risk-neutral, with a common rate of time preference, r. The solution of interest is a subgame-perfect equilibrium with a stationary contract between the firm and its employees.

Each worker is endowed with an indivisible unit of labor-leisure. If employed in a period, a worker must choose her level of effort, denoted by e, at the beginning of the period. For simplicity, take $e \in \{0, 1\}$, where $e = 0$ indicates the worker is taking leisure (shirking) while $e = 1$ indicates the worker is putting forth effort. The worker's per-period utility is $y - v_e$, where $y \in (-\infty, \infty)$ is her income and v_e is her measure of effort disutility.

We assume $v_0 = 0$ and $v_1 = v > 0$. When the worker is unemployed, her income and effort level are both equal to zero.

No employee's effort choice is observed. However, each employee generates an unverifiable, imperfectly-informative signal, σ, about her effort choice. We assume that this signal is observed by the firm *and all employees.* For simplicity, we assume $\sigma = 1$ with certainty when $e = 1$, while $\sigma = 0$ with a probability, $\theta > 0$, and $\sigma = 1$ with the complementary probability, $1 - \theta$, when $e = 0$.

The firm has a production function, f, with sole argument the effective labor input, $E = \int_0^L e(l)d\mu(l)$, where L is the measure of workers employed at the firm, $e(l)$ is the effort choice of the lth employee, and μ denotes Lesbegue measure. The production function is assumed to satisfy the following standard conditions:

$$f(0) = 0, \quad f' > 0, \quad f'' < 0, \quad \lim_{E \to \infty} f'(E) = 0, \quad \text{and} \quad \lim_{E \to 0} f'(E) = \infty.$$

We assume that all employees operate under the same terms of contract. Let z denote this common contract between the firm and its employees. We assume z is time invariant. Following M&M, we partition z into explicit components, which are verifiable (and enforceable) by the courts, and implicit components, by which no credible commitment can be made. The explicit components of the contract are an up-front wage, $w^0 \in (-\infty, \infty)$, to be paid by the firm to a worker in each period when the worker is employed by the firm and, in this section, the level of employment at the firm, L. The implicit components consist of a promise by each worker to put forth effort and a bonus wage, $w^1 \in (-\infty, \infty)$, to be paid to an employee contingent on that employee not shirking.[5]

Given the contract z, our model is an infintely repeated game where each of the one-period games itself contains several stages. The sequence of events in each period game is as follows. First, the firm decides to retain or to fire each worker who was employed by the firm in the previous period. On the basis of this firm decision, all workers employed by the firm in the previous period can tell whether the firm has cheated, since within this subpopulation it is common knowledge which workers, if any, were detected shirking. Second,

[5] M&M consider another explicit component, a severance pay. For incentives, (negative) severance pay and (positive) bonuses are perfect substitutes. The issue is whether the (explicit) bond is posted upon entering into the contractual relationship or if the (implicit) bond is paid only at the time of separation. The latter may not be possible when workers face limited liability.

each worker who was retained by the firm decides whether to stay or to quit. Workers who are separated from the firm earn a payoff that is specified exogenously and is independent of whether it was the firm or the worker who initiated the separation. Third, if all workers employed in the previous period have separated, the infinitely repeated game ends. The firm receives a payoff that is specified exogenously. We interpret this payoff as the present value of a firm which has "lost it's reputation." If there have been some retentions, the firm is then free to hire new employees. If there were also some separations, potential new employees do not know whether the separations were caused by firm cheating, but they do know there have been some retentions. The firm can fill as many positions as it desires, as long as there are potential employees who are willing to fill these positions. Once either the list of positions or the list of potential employees is exhausted, play proceeds to the production stage. In the first period of firm operation, the third stage is modified to allow the firm to hire new employees, although there are no retained employees, by letting new workers know the firm is just setting up shop. Fourth, having reached the production stage the firm pays all its current employees the up-front wage. Fifth, current employees apply effort or shirk. Both the output and effort signals are realized. Also, the actual level of employment is verified and a very large penalty, exceeding the value of the aggregate bonus, is imposed on the firm in case actual employment deviates from the level specified in the contract. Last, the firm decides whether to pay the bonus or not to each current employee.

We denote the lifetime reservation utilities of the firm and individual workers by Π^0 and U^0, respectively. The reservation utilities in each period are defined by $\pi^0 = r\Pi^0/(1+r)$ and $u^0 = rU^0/(1+r)$, respectively. We assume $\Pi^0 \geq 0$ and $U^0 \geq 0$, with at least one of these inequalities being strict.

We are interested in contracts with positive employment which yield a subgame perfect equilibrium that, along the equilibrium path, calls for honest play, no turnover, and no new hires after the initial period. We refer to such a contract as self-enforcing. A self-enforcing contract is considered violated if an employee is detected shirking or if the firm cheats by paying a bonus less than w^1 to an employee who has not been detected shirking. The mechanism that makes the contract self-enforcing is a simple process of belief formation that generates the familiar "trigger strategy." The triggers are determined as follows. The firm believes an employee will shirk if that employee has been detected shirking at any time

in the past. Similarly, an employee believes the firm will cheat if that employee was not detected shirking yet did not receive the bonus in some previous period. To simplify the analysis and to strengthen the possibility of bonding, we assume all employees come to the belief that the firm will cheat on them if the firm has cheated on any of its employees.[6] Employees continue to assume that the firm will behave honestly when any worker who has been fired is known to have shirked and the firm continues to assume that an employee will put forth effort if she has never been detected shirking. In addition, a potential new employee who has been offered a job (this only occurs if there are some retained workers) assumes that the firm will behave honestly. The new employees attribute any turnover at the firm to malfeasance by former employees.

When a contract, z, is self-enforcing, it provides a profit for the firm, $f(L)-(w^0+w^1)L$, and a job rent for each employee, $w^0 + w^1 - u - v^0$, per period. The aggregate lifetime surplus generated by such a contract is

$$S(L) \equiv \frac{1+r}{r}[f(L) - (u^0 + v)L - \pi^0].$$

In the absence of moral hazard, the employment component of an efficient contract maximizes the aggregate surplus. This employment level can be represented $L^* \equiv \hat{L}(v + u^0)$, where $\hat{L}(w)$ is the solution to the one-period profit maximization problem given the total wage cost, $w = w^0 + w^1$:

$$\hat{L}(w) \equiv \arg\max_{\ell} \quad f(\ell) - w\ell. \tag{1}$$

If an employee (potential new hire) believes the firm will cheat, she is better off quitting (not accepting the contract) when $w^0 < u^0$ and accepting and shirking when $w^0 \geq u^0$. Similarly, if the firm believes an old employee (a potential new employee) will shirk, it is better off firing (not hiring) the worker when the up-front wage is positive. Consequently, subsequent to a period of firm cheating, the firm and all its employees earn their lifetime reservation utilities.

By our assumptions, if the firm decides to cheat on some employees it is better off

[6] If the response of employees is weaker, the firm's loss from cheating will be smaller and potential employees will be more hesitant to post bonds.

cheating on all of them. Therefore, the firm will pay the bonus only if

$$w^1 L \leq \frac{\Pi^1 - \Pi^0}{1+r}, \tag{2}$$

where Π^1 denotes the lifetime profit of the firm starting in the following period when it continues to operate under the contract.

When (2) is violated, employees will find it optimal to set $e = 0$. When (2) is satisfied, employees will fulfill the contract only if

$$\frac{v}{\theta} \leq w^1 + \frac{U^1 - U^0}{1+r}, \tag{3}$$

where U^1 is the lifetime value of the worker starting in the following period when she continues to operate under the contract. Note that v/θ is the minimum value of bond necessary to overcome shirking.

For a w^1 to exist such that (2) and (3) both hold, it is necessary that

$$\frac{\Pi^1 - \Pi^0}{1+r} + \frac{U^1 - U^0}{1+r} L \geq \frac{v}{\theta} L. \tag{4}$$

When (2) and (3) are satisfied, we have[7]

$$\Pi^1 = \frac{1+r}{r}[f(L) - (w^0 + w^1)L] \quad \text{and} \quad U^1 = \frac{1+r}{r}(w^0 + w^1 - v). \tag{5}$$

Therefore, (4) can be written as

$$\frac{r}{1+r} S(L) = f(L) - (u^0 + v)L - \pi^0 \geq \frac{r}{\theta} v L. \tag{6}$$

When the firm's reservation utility is too great, there is no employment level that satisfies (6), in which case there does not exist a self-enforcing contract. However, when the firm's reservation utility is near zero, our assumptions on the production function ensure that (6) can be satisfied. Then, since the production funtion is strictly concave, (6) defines a contiguous range of employment levels for which self-enforcing contracts exit. We denote the lower limit of this range by $\underline{L}$ and the upper limit by $\bar{L}$. These limits are defined by the two levels of employment at which (6) holds as an equality. We refer to (6) as the Aggregate Surplus Condition (ASC).

[7] Note that we have substituted L for E because all workers are expected to put forth effort as they are employed under the same contract and the same conditions.

A contract, z, that satisfies (2) and (3) is acceptable to workers if the sum of the up-front wage, the expected bonus, and the expected future job rent is at least as large as the sum of the disutility of effort and the worker's reservation utility. Using (5), this condition can simply be written as

$$w^0 + w^1 - v \geq u^0. \tag{7}$$

Similarly, to be profitable for the firm, the contract, z, must satisfy

$$f(L) - (w^0 + w^1)L \geq \pi^0. \tag{8}$$

When employment is such that the ASC does not bind, there is a range of feasible bonuses such that (2) and (3) are satisfied. When w^1 changes by a small amount without violating (2) or (3), an equal but opposite change in w^0 does not affect the acceptability or profitability of the contract. For clarity of exposition and without loss of generality, we restrict attention to contracts with the minimum bonus. That is,

$$w^1(w^0) = \frac{1}{1+r}\left[u^0 + v + \frac{rv}{\theta} - w^0\right]. \tag{9}$$

Under this assumption, total compensation can be expressed as a function of the up-front payment

$$w(w^0) \equiv w^0 + w^1(w^0) = \frac{1}{1+r}(u^0 + v + \frac{rv}{\theta} + rw^0). \tag{10}$$

Note that $w(w^0)$ is increasing in w^0 and contains a job rent if

$$w^0 > \bar{w}^0 \equiv u^0 + v - \frac{v}{\theta}. \tag{11}$$

When all the compensation is in the form of up-front payment, $w(w^0) = w^0$, w^0 is equal to the efficiency wage given by

$$w^e \equiv u^0 + v + \frac{rv}{\theta}.$$

In this case, job rent equals the minimum necessary bond, v/θ.

Given (9), the allocation resulting from the contract, z, can be summarized by the pair, (L, w^0). Then, conditions (7) and (8) are equivalent to

$$\frac{S(L)}{L} \geq w^0 - u^0 - v + \frac{v}{\theta} \geq 0. \tag{12}$$

We refer to (12) as the Individual Rationality Condition (IRC).

Any pair, (L, w^0), that satisfies both the ASC and the IRC can serve as a basis of a self-enforcing contract. In (L, w^0) space, the ASC can be represented by the area between the vertical lines at $\underline{L}$ and $\bar{L}$, as graphed in Figure 1. The IRC consists of the area between a horizontal line at $w^0 = \bar{w}^0$, which is the boundary of the workers' individual rationality condition (IRC_W), and an inverted-U-shape upper limit, which is the boundary of the firm's individual rationality condition (IRC_F).[8] The feasible set is the area enclosed by IRC_W and IRC_F between $\underline{L}$ and $\bar{L}$. Note that in the range of employment levels that satisfy the ASC, there is always a w^0 that satisfies the IRC. Thus, the existence of a self-enforcing contract is solely contingent on the ASC holding for some L. This requires

$$\max_L \left\{ f(L) - (u^0 + v + \frac{r}{\theta} v)L \right\} \geq \pi^0. \tag{13}$$

We say that the self-enforcing contract, z, is incentive-efficient if, within the class of self-enforcing contracts, it maximizes the profit of the firm for a given total worker surplus. In this definition, aggregation across employees in determining the worker' surplus might be a source of ambiguity, because there might be a self-enforcing contract that is more profitable than z and entails a higher wage but lower employment or, alternatively, a lower wage but greater employment. Nonetheless, this seems like a sensible working definition with which to compare the multiple employee and single employee cases.

The iso-surplus curves for workers as a group are rectangular hyperbolas represented by $w^0 = \bar{w}^0 + (1 + r)s/rL$, where s is the level of total worker surplus. The iso-profit curves, on the other hand, are inverted-U curves, similar to the IRC_F, peaking on the labor demand curve, L^d. When an iso-surplus curve and an iso-profit curve are tangent, the tangency occurs at $L = L^*$, where L^*, is determined by the intersection of IRC_W and L^d. When the interest on the bond, rv/θ, is small, L^* satisfies the ASC, as in Figure 2.[9] Then, incentive-efficient allocations are those with $L = L^*$ and any w^0 acceptable to both sides.

[8] The slope of IRC_F is given by $dw^0/dL = (1 + r)[f'(L) - w(w^0)]/rL$, which changes signs from positive to negative as L passes the labor demand curve, L^d, which is the locus of $(\hat{L}(w(w^0), w^0)$.

[9] For simplicity, we have taken the detection lag for both firm and worker cheating to be one period. If these lags differ so that verification of firm employment can occur much quicker than detection of worker cheating, the interest on the bond over the relevant period will be small.

Otherwise, $L^* > \bar{L}$, as in Figure 1. Then, the locus of incentive-efficient allocations is the vertical line segment at $L = \bar{L}$ between IRC_W and IRC_F. In either case the employment component of incentive-efficient contracts, denoted by L^{**}, maximizes the aggregate surplus subject to the ASC.[10]

$$(14) \quad L^{**} = \arg\max_L f(L) - (u^0 + v)L - \pi^0 \text{ subject to } f(L) - (u^0 + v)L - \pi^0 \geq \frac{r}{\theta} vL.$$

The above observations help us state the following proposition:

Proposition 1. *Under our standing assumptions,*

(a) There exists a self-enforcing contract if and only if (13) holds.

(b) For every self-enforcing contract, $\tilde{z}$, the contract, $\hat{z}$, is also self-enforcing when $\tilde{L} = \hat{L}$ and $\hat{z}$ satisfies the IRC.

(c) When (13) holds, $\tilde{z}$ is incentive-efficient if and only if $\tilde{L} = L^{**} = \min\{L^*, \bar{L}\}$ and $\tilde{z}$ satisfies the IRC.

Proposition 1 indicates that any employment level satisfying the ASC combined with any up-front wage that is individually rational for both the firm and its employees can serve as the basis of a self-enforcing contract. In other words, the division of surplus between the firm and its workers has no impact on whether the contract is sustainable or efficient. Note that under condition (13), the model has an incentive-efficient allocation at $(L^{**}, \bar{w}^0)$, where all the surplus is appropriated by the firm. At this allocation employees are fully bonded because $\bar{w}^0$ is equal to the cost of labor less the minimum bond necessary for overcoming worker moral hazard. Moreover, when θ is small, the up-front wage will be negative; i.e., employees will be posting explicit bonds. This is the situation depicted in Figure 1.

3. Limited Employment Commitment and Surplus Distribution

The assumption that the firm can commit to a specific employment level is crucial in obtaining the result that any division of surplus is possible in a self-enforcing contract. This commitment assumption is very strong. To show this, we continue with the same model as in section 2, modified only by the assumption that there is an upper limit, B,

[10] Given our assumptions concerning f and v and assuming (13) holds, the solution to (14) is unique.

on the amount for which the firm can be held liable in case actual employment deviates from the level specified in the contract, L.[11] We assume the maximum fine is imposed for any amount of deviation. This provides the greatest incentive for the firm to abide by the employment level specified in the contract. As in the previous section, we maintain the assumption that the actual employment of the firm can be verified within the same period, but only after production has occurred, and we again restrict attention to self-enforcing contracts sustained by trigger-strategies. To keep matters simple, we assume whenever actual employment violates the contract, the firm will lose its reputation in the subsequent period and, consequently, will find it optimal to renege on any bonus payment.[12]

Under the limited liability assumption, the lifetime payoffs and the acceptability conditions for self-enforcing contracts are the same as those given in (5), (7), and (8). The workers' incentive compatibility condition is also the same as (3). But, while (2) is still a necessary condition for the firm to abide by the contract, there is another necessary condition. The lifetime payoff to the firm from abiding by the contract employment level and paying the bonus must exceed the profit from violating the employment stipulation. Note that if the firm intended to renege on the bonus and disregard the employment level, it would set employment to $\hat{L}(w^0)$, knowing both that it will be forced to pay B and that it will suffer a loss of reputation as an honest employer. We assume as before that the worker incentive compatibility condition holds as an equality and, thus, w^1 is given by its miminum level defined by (9). This implies that for fixed total compensation per worker, the up-front wage is maximal and, consequently, the firm faces the maximal incentive to keep employment at the level specified in the contract.[13] Thus, the firm's incentive compatibility condition is both (2) and

$$(15) \qquad \frac{1+r}{r}[f(L) - w(w^0)L] \geq f(\hat{L}(w^0)) - w^0\hat{L}(w^0) - B + \frac{\pi^0}{r}.$$

[11] We are assuming that the firm is punished whether it exceeds or falls short of the contract employment level. The consequences of assuming punishment only in case of overemployment will be discussed in the following section.

[12] Since we are primarily concerned with the range of feasible up-front payments, this is a sensible assumption. Were one to switch focus to sustainable employment levels, a concern is whether the firm will actually suffer a reputation loss when it does not cheat on the bonus but only on the employment level. If there is no reputation loss in this case, it is not possible to sustain allocations too far from the L^d curve.

[13] This statement presumes the up-front wage is less than the efficiency wage.

Given (9), a contract, z, is self-enforcing if (L, w^0) satisies (12), (6), and (15).

Observe that $\hat{L}(w^0)$ is only well defined when w^0 is positive. Otherwise, the gain to firm cheating on both bonus and employment is unbounded. Since the gain from fulfilling the contract is bounded as long (7) and (8) are satisfied, condition (15) cannot be satisfied when $w^0 \leq 0$. That is, there cannot be explicit bonding in equilibrium. This gives our key result:

Proposition 2. (Absence of Explicit Bonds) *Under our standing assumptions, the up-front wage is positive in any self-enforcing contract, regardless of the limited liability level, $B < \infty$.*

In the rest of this section, we characterize the set of self-enforcing contracts under the limited liability assumption. First note that all allocations on the $\hat{L}(w^0)$ locus within the feasible set under unlimited liability are also feasible under limited liability, because in this case (15) is the same as (6) except for B being subtracted from its right-hand side. For example, the allocation $(\hat{L}(w^e), w^e)$ can be sustained by a self-enforcing contract under limited liability, assuming (13) holds. Therefore, condition (13) is sufficient for the existence of a self-enforcing contract regardless of the liability limit. This yields:

Lemma 1. *Under limited firm liability, $B < \infty$, a self-enforcing contract exists if and only if (13) holds.*

We refer to the boundary of the set of allocations that satisfy (15) as the limited liability curve (LLC). When $B < \pi^0/r$, the LLC is an oval-shaped curve, as in Figure 3, centered around $(\hat{L}(w^e), w^e)$, the crossing point of L^d and $\hat{L}(w^0)$. The LLC is flat at its crossing points with L^d and vertical at its crossing points with $\hat{L}(w^0)$. To see this, note that the slope of LLC is given by

$$\frac{dw^0}{dL} = \frac{1+r}{r}\left[\frac{f'(L) - w(w^0)}{L - \hat{L}(w^0)}\right]. \tag{16}$$

When $B = 0$, the LLC is entirely contained in the ASC and is tangent to the ASC boundary, $L = \underline{L}$ and $L = \bar{L}$, at the crossing points of this boundary with $\hat{L}(w^0)$. Increasing B expands the LLC, especially along $\hat{L}(w^0)$ in the range of $L > \bar{L}$ and along L^d for $L < \underline{L}$. As B rises (or π^0 declines), the minimum point of LLC, (L^m, w^m), moves down along L^d, but always

remains above $w^0 = 0$. On the other hand, the maximum point of the LLC rises along L^d without bound. Specifically, no maximum point exists when $B > \pi^0/r$.

When $L^* > \bar{L}$, all allocations with w^0 in the feasible range and $L = \bar{L}$ are incentive-efficient. If B is large enough that $L^m \geq \bar{L}$, then the minimum up-front wage among feasible contracts is determined by the smaller of the points where the LLC crosses the $\bar{L}$ line (see Figure 4). This crossing point also yields maximal profit among feasible allocations. Incentive-efficient allocations in this case consist of all those on $L = \bar{L}$ inside the LLC and below IRC_F. On the other hand, if B is sufficiently small such that $L^m < \bar{L}$, then (L^m, w^m) will be feasible and will give the minimum up-front wage among all feasible allocations. This is the case graphed in Figure 5. In this case, (L^m, w^m) is the most profitable feasible allocation and all points along the lower part of the LLC between L^m and $\bar{L}$ are also incentive-efficient. Obviously, these points are not incentive-efficient under the unlimited firm liability assumption.[14] The only difference to the prior description, when $L^* \leq \bar{L}$, is that L^* should replace $\bar{L}$ where appropriate.

When $w^m > \bar{w}^0$ and (L^m, w^m) is feasible, all self-enforcing contracts entail job rents for employees. Job rents are also necessary even when (L^m, w^m) is not feasible, as long as $(\bar{L}, \bar{w}^0)$ violates (15). Thus, we obtain

Proposition 3. *Assuming limited firm liability and (13), workers receive job rents under all self-enforcing contracts when*

$$(17) \qquad \frac{1+r}{r}[f(L^{**}) - (u^0 + v)L^{**}] < f(\hat{L}(\bar{w}^0)) - \bar{w}^0\hat{L}(\bar{w}^0) - B + \frac{\pi^0}{r}.$$

The inequality in (17) holds when θ and B are sufficiently small. In particular, when $\theta \leq v/(u^0 + v)$, (17) will be satisfied regardless of B. Note that in this case, $\bar{w}^0 \leq 0$ and there would be explicit bonding under full commitment if all the surplus were assigned to the firm.

Though our main points are well summarized in propositions 2 and 3, we note that much of the rest of the literature assigns the firm monopsony power in choosing the contract.

[14] For small values of B, there may exist another incentive-efficient allocation along the upper part of the LLC to the left of $L = \bar{L}$ if such points fall below IRC_F. Again, such an allocation is not incentive-efficient under unlimited liability.

Hence, it is of interest to examine the comparative statics properties of the most profitable self-enforcing contract. As we have already noted, when $(L^*, \bar{w}^0)$ is not feasible, this contract will either be (L^m, w^m) or the lower of the two allocations where the LLC crosses the $\bar{L}$ line. Using (10), (15) gets tighter as v, u^0, r, and π^0 increase and gets more slack as θ and B increase.[15] Likewise, the ASC gets tighter as v, u^0, r, and π^0 increase and gets more slack as θ increases. From this we conclude

Proposition 4. *Under limited firm liability, when $(L^*, \bar{w}^0)$ is not feasible, the up-front wage of the profit maximizing self-enforcing contract is increasing in v, u^0, r, and π^0 and is decreasing in θ and B.*

Note that the efficiency wage, w^e, is also increasing in v, u^0, and r and is decreasing in θ. But the efficiency wage is independent of π^0 and B.

Bargaining models of wage determination predict an inverse relationship between the wage and the firm's outside alternative.[16] That our model predicts a direct relationship offers a potential test of our model, if one accepts the monopsony-firm assumption. Note that bargaining models also predict a direct relationship between the wage and the firm's productivity under contracts with the insiders. But for the profit maximizing contract in our model, this relationship depends on the size of liability limit and the shape of the production function. To illustrate this point, imagine there is a multiplicative productivity parameter, p, so that output is $pf(L)$ when the effective labor input is L. Then, w^m is determined by the equation

$$(18)\quad \frac{1+r}{r}\left[pf\left(\hat{L}(w(w^m))\right) - w(w^m)\hat{L}\left(w(w^m)\right)\right] = pf\left(\hat{L}(w^m)\right) - w^m\hat{L}\left(w^m\right) - B + \frac{\pi^0}{r}.$$

Differentiating implicitly with respect to p while keeping π^0 constant and exploiting the

[15] For example, the derivative of w^0, as determined by (15) given L, with respect to r can expressed as

$$\frac{dw^0}{dr} = \frac{f(L) - w(w^0)L - \pi^0 + r(1+r)(w^0 - \bar{w}^0)L}{r^2(\hat{L}(w^0) - L)},$$

which is always positive when (12) is satisfied.

[16] See Malcomson (1992) for a survey of this line of argument.

envelope theorem we get

$$(19)\quad \frac{dw^m}{dp} = \frac{f\left(\hat{L}(w^m)\right) - (1+r)f\left(\hat{L}(w(w^m))\right)/r}{\hat{L}(w^m) - \hat{L}\left(w(w^m)\right)} = \frac{f(\hat{L}(w^m))(\eta_0 - \eta_1) - B + \pi^0/r}{p(1-\eta_1)[L(w^m) - L(w(w^m))]},$$

where η_0 and η_1 are output elasticities with respect to employment at $L(w^m)$ and $L(w(w^m))$, respectively. From this we conclude

Proposition 5. *w^m is decreasing (increasing) in p when π^0/r is bigger (less) than B and η is nondecreasing (nonincreasing) in L.*

Recall that w^m is not feasible when B is large enough. Thus, the results in proposition 5 should be treated with care. But, these results do suggest the possibility that the relationship between firm productivity and the wage rate may be the inverse of that predicted by bargaining models. Also, proposition 5 indicates how the predicted wage in our model differs from the pure efficiency wage, w^e, and the up-front wage under pure bonding, $\bar{w}^0$. In wage determination, the size of the surplus generated by the firm, its outside alternatives, and its liability limit matter in our model, but not in pure efficiency wage and pure bonding models.

4. Discussion and Conclusion

While collective bargaining agreements may contain an employment stipulation, actual non-union labor contracts rarely specify firm employment, with explicit penalties for deviations. This may be due to verification costs. It may be that one significant role unions play is to internalize these verification costs. Thus, our model with full commitment might actually apply best to unionized firms. When verification costs must be borne by the firm to attain full commitment, the firm might find it more profitable to eschew the verification costs and instead pay higher wages to convince employees that the surplus condition is satisfied. Explicit consideration of verification costs might then serve as a means for selecting between the models of section 2 and 3.

If actual contracts specify wages but not employment, the firm really has more discretion than our model in section 3 suggests. In this case, actual employment will invariably place the firm on its labor demand curve, L^d. That is, the solution to the model will be the segment of L^d enclosed by the ASC, IRC, and LLC curves. When (L^m, w^m) satisfies (6) and

(12), this contract is still the most profitable, feasible outcome. Otherwise, the minimum feasible up-front wage is even greater than what we predicted it would be in section 3. It should also be noted that in this case the feasible contract with the lowest wage rate is always incentive-efficient. Additional points on the feasible set may also be incentive-efficient if the workers' surplus increases along L^d as the up-front wage rises to w^e.

An intermediate possibility is that employment is observable by current employees, after a brief lag, but is not verifiable by third parties, without a much lenghtier lag, with an implicit agreement entailing only an upper limit on employment, just as the implicit agreement specifies a lower limit on effort. Then, there are feasible allocations to the left of L^d and such allocations are not incentive-efficient, but allocations to the right of L^d are not feasible, since the firm could profit by reducing employment though otherwise obeying the terms of the contract. In this case, the set of incentive-efficient contracts is the same as in the case where the firm has full discretion over employment. In this sense, the two cases are observationally equivalent.

The extent of the firm's commitment to employment is important for empirically measuring the loss in efficiency due to the worker-shirking problem. In recent years a number of tests of labor market efficiency have been conducted by comparing the actual wage rate of a sample of workers with some estimate of their reservation wage (Hendricks and Kahn, 1992). If allocations necessarily end up on the marginal product curve, this procedure is sensible. But if the firm has greater commitment to employment, higher wages need not imply lower efficiency, as demonstrated by the analysis in this paper. Then, a correct procedure requires a direct measurement of the marginal product of labor. This point has broader applicability in regard to the estimation of cost functions. The usual estimation of cost functions independent of the product price may yield biased results, since the presence of shirking may constrain the employment of labor and such constraints depend on profitability.

We have argued that the nature of the firm's production function is important in wage determination. If production is additive, performance bonds and piece rate contracts are possible. But when there is some jointness in production, there is one aggregate surplus condition rather than a separate surplus condition for each employee. Indeed, in a richer model, this aggregate surplus condition will include inputs other than labor and input suppliers other than employees, as long as production is not additive in these other inpurts.

Under an aggregate surplus condition, the firm has a greater scope to cheat. Since the profitability of cheating increases with volume, the terms of the contract will be set to make it less attractive for the firm to hire more workers, with the intention of cheating on them. This is what rules out explicit bonds. Once this point is recognized, we readily admit that our formal model may have overstated the potential gains to firm cheating in actuality. By assuming the marginal product of labor is positive globally, we were able to conclude that the gains to firm cheating are unbounded under bonding. If, to the contrary, employing workers beyond some point is costly to the firm, then some degree of bonding may be possible. But an unbounded gain to firm cheating under bonding is certainly not necessary to rule out bonds. The absence of bonds in actuality suggests these gains to firm cheating are quite large.

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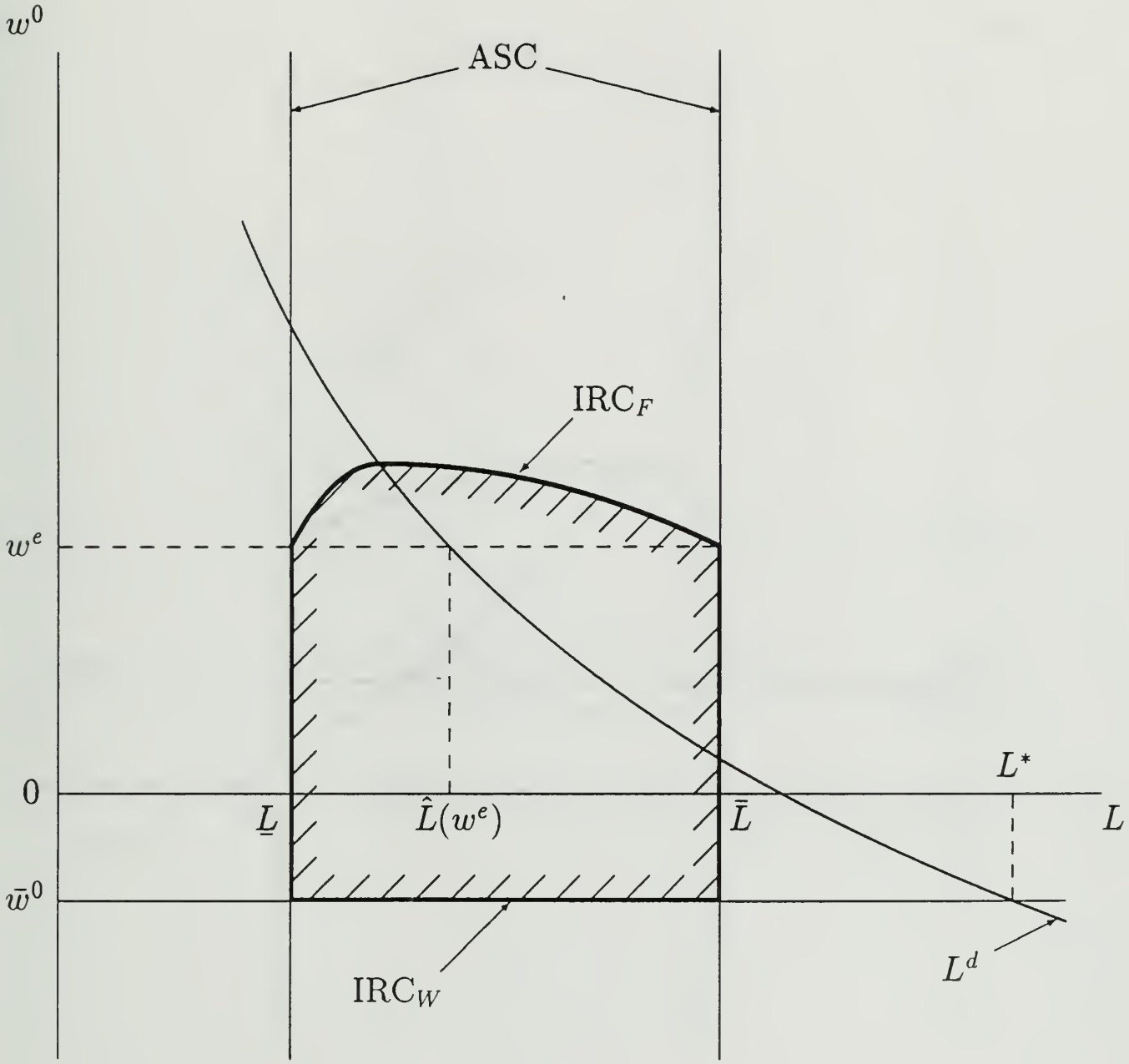

Figure 1. Equilibrium Contract Determination
with Employment Commitment

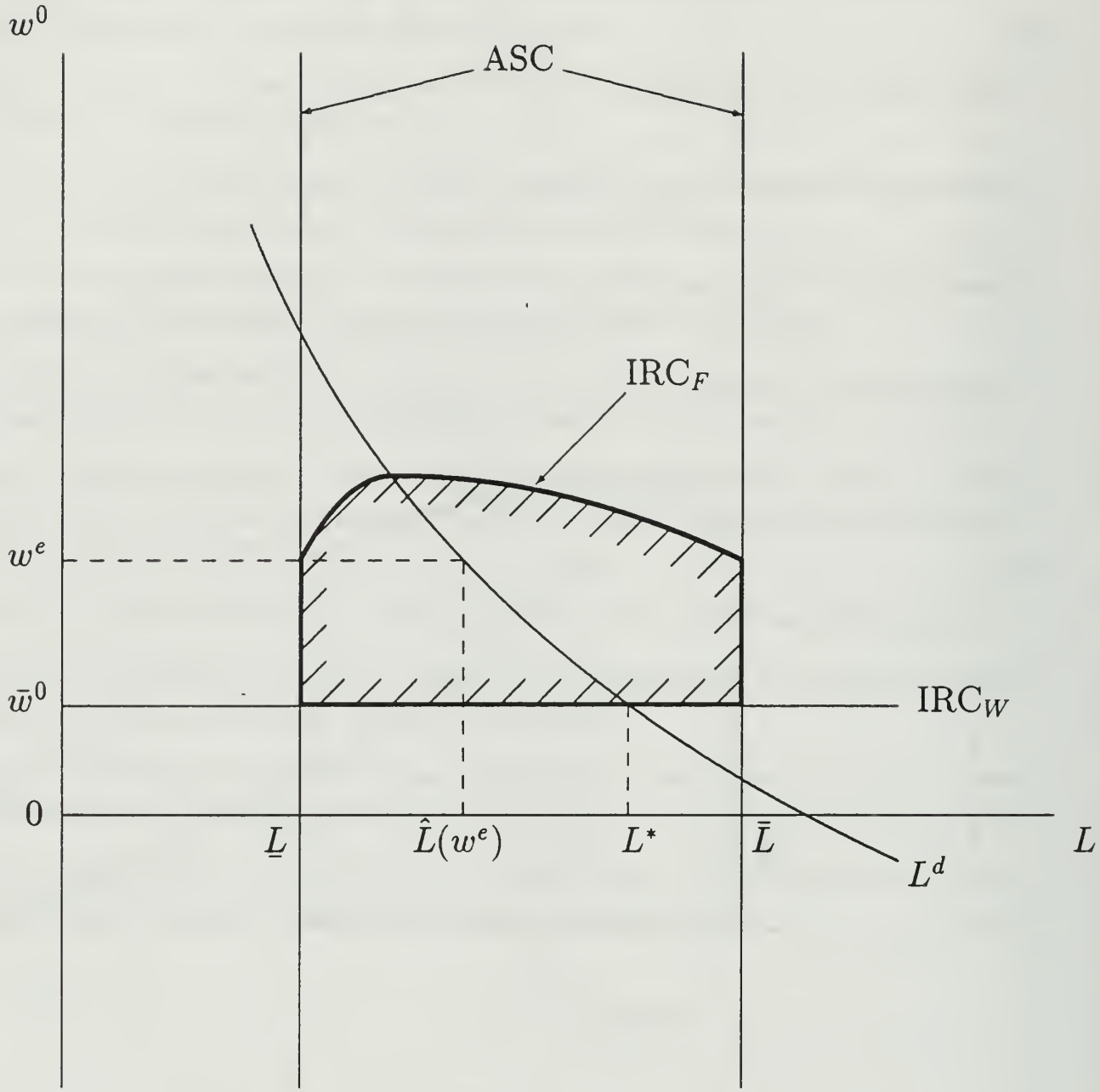

Figure 2. Equilibrium Contract Determination with Employment Commitment: A Case with Feasible First-Best Employment

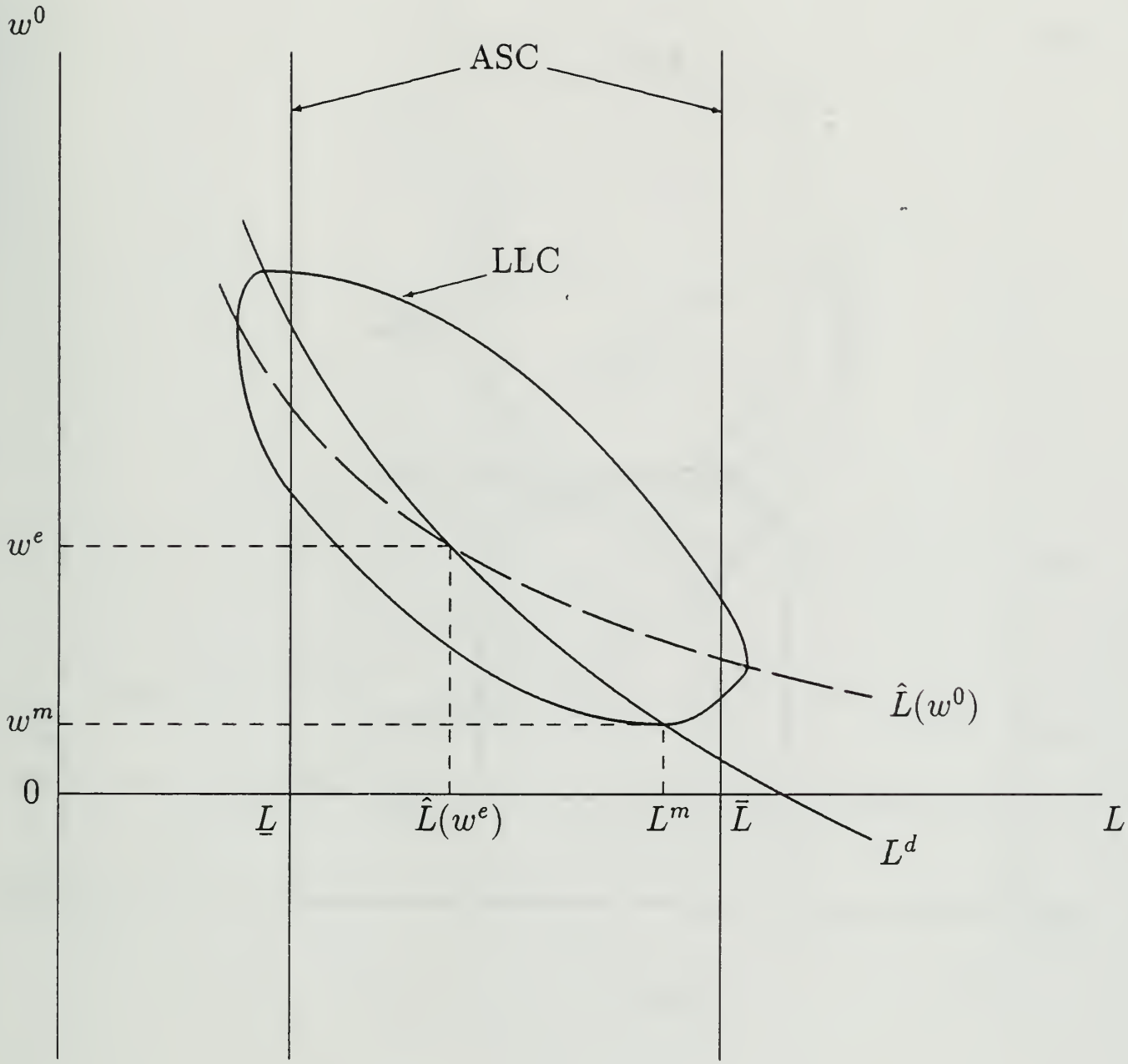

Figure 3. The Limited Liability and Aggregate Surplus Constraints

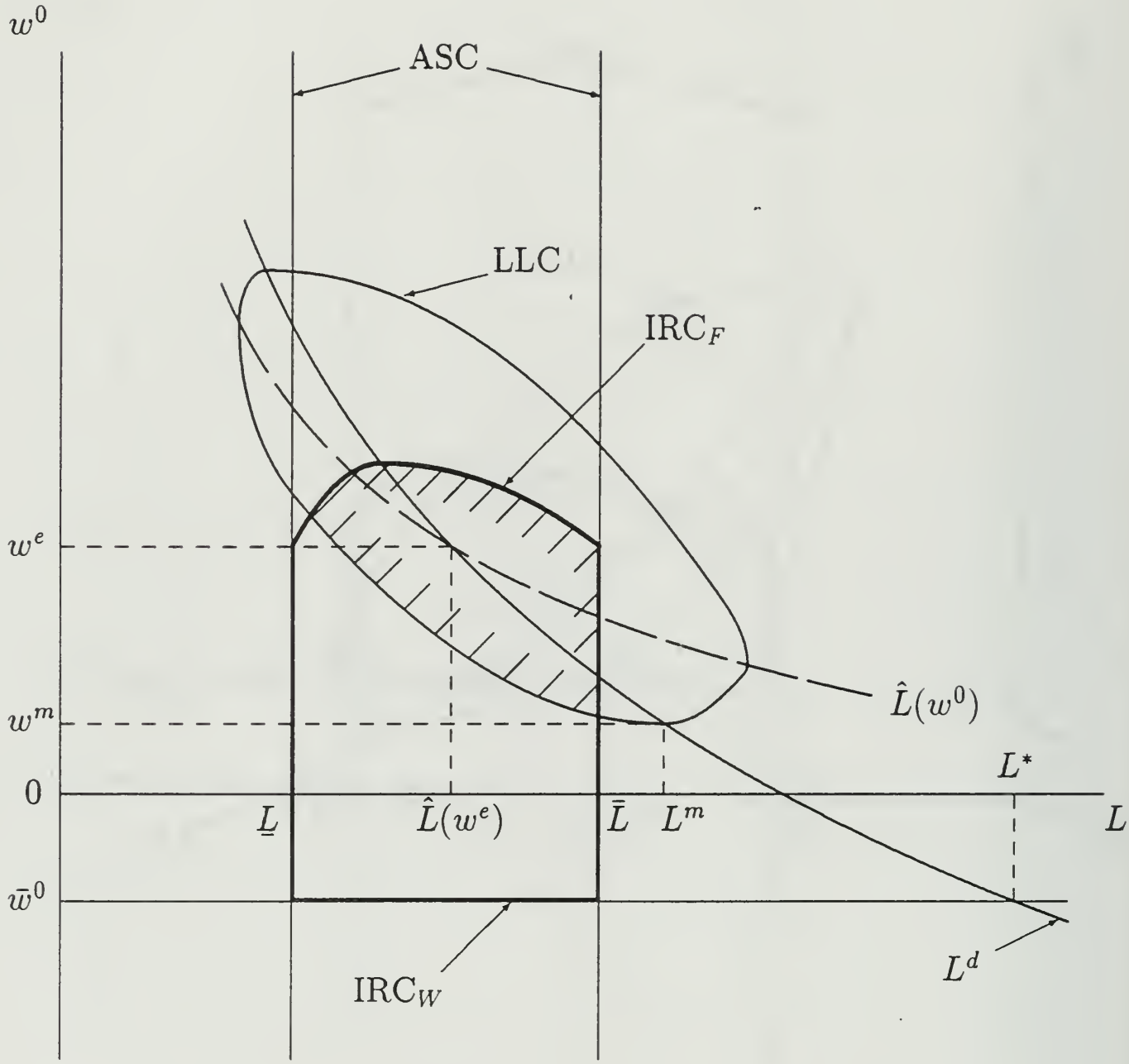

Figure 4. Equilibrium Contract Determination Under Limited Liability: A Case where $L^m > \bar{L}$

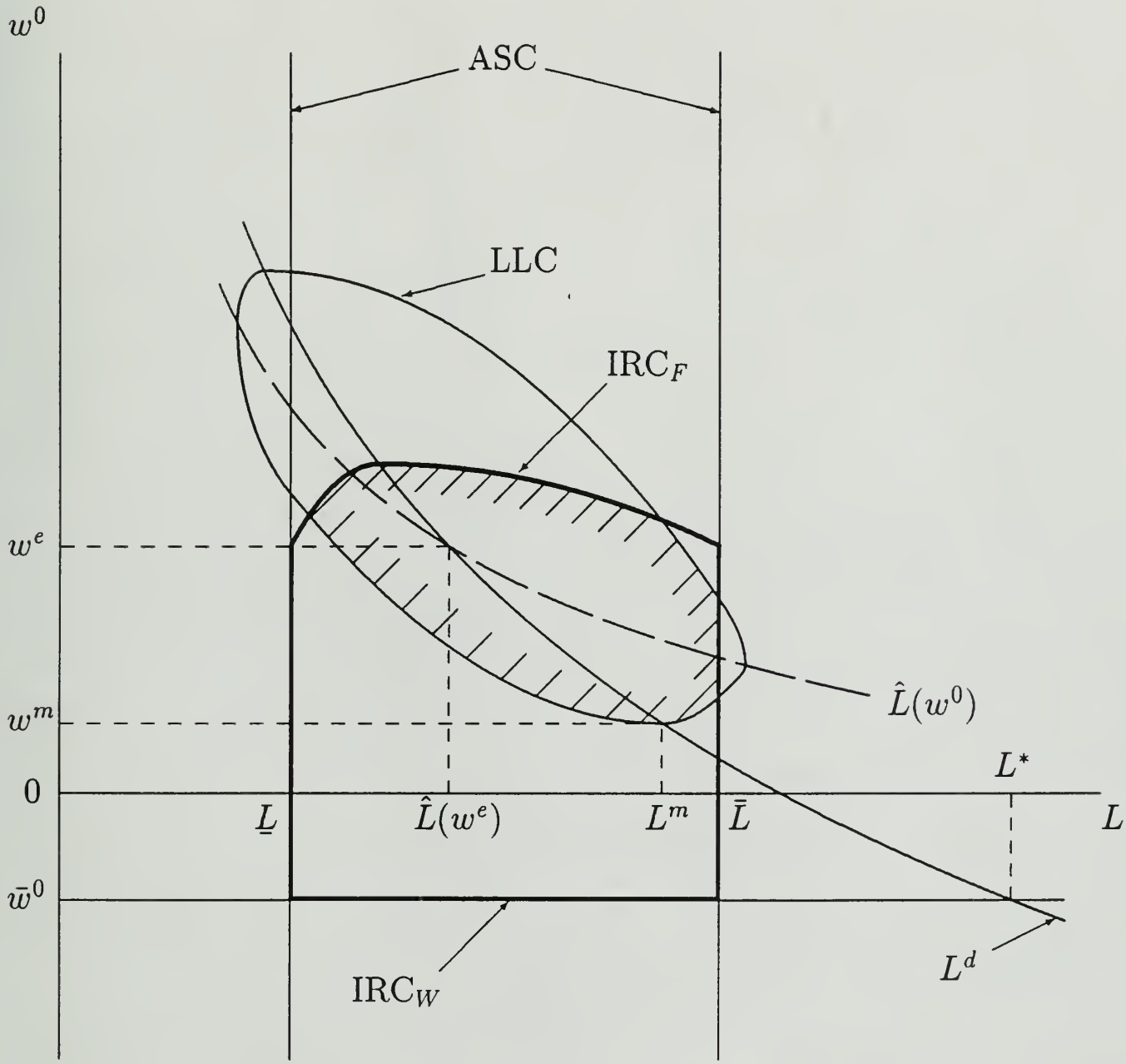

Figure 5. Equilibrium Contract Determination Under Limited Liability: A Case where $L^m < \bar{L}$

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